3.9 Study 4 Experimental Methodology and Approach

Unexpected Braking Event with "Unexplained" FCW Crash Alerts / Braking in Response to Expected FCW Crash Alerts Under Lead Vehicle Moving Conditions

Building upon the solid foundation provided by the results obtained from CAMP Study 1, Study 2, and Study 3, this study further examined how and when to present crash alert information to both an attentive and relatively inattentive driver. An overview of the experimental methodology and approach used in this study is shown in Table 3-11, and an overview of the order of experiment events (or procedures) in this study is shown in Table 3-12. As in Study 2, a subset of the test participants used in CAMP Study 1 was tested (who were not participants in either Study 2 or Study 3). As in Study 3, drivers in this study were <u>not</u> informed at the beginning of the study that the purpose of this research was to address the usefulness of FCW system crash alerts for helping drivers avoid rear-end collisions.

As in Study 3, the Surprise Moving Trial occurred during the first phase of the study. Once again, the on-board computer was allegedly "learning" driver's normal following behavior for a later "automatic distance control" phase, and the backseat experimenter engaged the driver in a structured Q & A background information dialogue. The backseat experimenter engaged the driver in the exact same dialogue used in Study 3, except this dialog was interrupted by a request for the driver to search for a (non-existent) indicator light on the dashboard. As the driver was visually searching for the indicator, the Surprise Moving Trial was introduced. As in Study 3, drivers were completely unaware the vehicle was equipped with a FCW system crash alert. After the Surprise Moving Trial, drivers were then asked the series of questions used in Study 3 about what they noticed come on inside the car before they began braking, and were also asked to provide a crash alert timing rating.

This Surprise Moving Trial was then followed by a number of trials in which drivers were asked to brake in response to a FCW system crash alert as an attentive driver while approaching the moving surrogate target. The driver was instructed to follow the POV at their "normal" following distance while the POV traveled at 30, 45, or 60 mph. After this headway had been attained, the POV braked automatically at a constant deceleration rate of approximately 0.15, 0.27, or 0.36 g's, in the same manner as was used in CAMP Study 1. These types of trials are subsequently referred to as *Alerted Moving Trials*. The nine combinations formed by crossing the three POV speed levels by the three POV deceleration levels were nearly identical to those examined in CAMP Study 1. Hence, driver's braking behavior with a crash alert could be compared to previous data obtained under identical conditions without a crash alert (for the same driver), which is discussed toward the end of this Chapter immediately prior to the General Discussion section. As in Study 2 and Study 3, immediately after a trial, drivers were asked to judge the appropriateness of the FCW system crash alert timing on a 7-point scale ranging from "much too early" to "much too late". Finally, it should be noted that rather than run Follow-On Moving Trials as in the previous two studies (Study 2 and Study 3), driver performance during the Surprise Moving Trial was compared to performance during the equivalent Speed/POV braking profile conditions evaluated in the Alerted Moving Trials phase. It was felt this latter condition would provide a more stable, valuable comparison to performance observed in the Surprise Moving Trial than would be found with Follow-On Moving Trials, although it should be noted that driver brake RT assumptions are different across Surprise Moving Trials and Alerted Moving Trials. Often drivers would need some time to get refocused on the task instructions after the Surprise Moving Trial, which may have affected the subsequent Follow-On Moving Trials data gathered immediately following the Surprise Moving Trial.

The timing of the crash alert information was again based on modeling results from CAMP Study 1, and utilized the most conservative crash alert timing approach used in Study 2 (i.e., the RDP crash alert timing), and the identical crash alert timing approach used in Study 3. The decision not to test a more aggressive crash alert timing approach, as was done in Study 2, was made after looking at early data from this study which suggested that the alert timing approach employed was perceived as between “just right” and “slightly late”. For the Alerted Moving Trials, as in the Alerted Stationary Trials of Study 2, driver RT was assumed to be 0.52 seconds for crash alert timing purposes. For the Surprise Moving Trial, driver RT was assumed to be 1.50 seconds (as in Study 2 and Study 3).

The two different 1-stage, dual-modality, FCW system crash alert types evaluated were the steady HHDD + Non-Speech and flashing HHDD + Non-Speech crash alert types, both “carryovers” from Study 3. The rationale for selecting these two FCW system crash alert types for this study was based on the following considerations. First, in terms of an experimental strategy (as well as experimental efficiency), focusing the study on two crash alert types allowed exploring the same wide range of POV speed/POV braking profile combinations explored in Study 1. This provided an important opportunity to evaluate and validate the crash alert timing approach under a much wider range of conditions when the lead vehicle was moving. Second, in both Study 2 and Study 3, the HHDD + Non-Speech crash alert type provided good all-around performance in terms of both objective data (e.g., fast brake RTs) and subjective data (e.g., low driver annoyance ratings). Third, the HHDD + Non-Speech crash alert type (whether the HHDD is steady or flashing) has favorable qualities as a crash alert type approach from an industry-wide, international implementation perspective relative to speech alerts (which, in any case, performed poorly in terms of both objective and subjective data), HUD alerts (HUDs are not currently implemented industry-wide), and the relatively immature brake pulse alert. Hence, in terms of developing minimum requirements, it made the most sense to concentrate on gathering additional data with the HHDD and non-speech dual-modality approach with a different surprise trial technique (i.e., the head-down visual search task), which might provide a different Surprise Moving Trial brake RT distribution. Fourth, the issue of whether or not to flash the HHDD alert could be explored further under a surprise trial technique where the anticipated visual angle between the driver’s eyes and both the visual crash alert location and the lead vehicle braking event location were substantially increased.

3.9.1 Subjects

Test participants consisted of 4 males and 4 females in each of three different age groups; 20-31, 40-51, and 60-71 years old. Corresponding mean ages for these younger, middle-aged, and older age groups were 25, 46, and 65 years old, respectively. Each driver was tested individually in one approximately 2 to 2 ½ hour session and paid $150 for their participation. Drivers were recruited by an outside market research recruiting firm, and were required to be CAMP Study 1 participants who had not participated in the previous Study 2. Drivers who were ultimately allowed to participate were mailed the information letter shown in Appendix A12 prior to testing. A copy of the informed consent statement is provided in Appendix A13, which describes the various conditions that ruled out potential drivers from participating (which were nearly identical to the conditions used in CAMP Study 1).

3.9.2 Test Site

Data was gathered on the same straightaway used in CAMP Study 1, Study 2, and Study 3. The road was closed to all other traffic during testing. All testing was conducted under daytime conditions under dry road and dry weather conditions.

3.9.3 Test Vehicles and the “Surrogate” (Lead Vehicle) Target

The SV, surrogate target, and POV were identical to that used in CAMP Study 1, Study 2, and Study 3. Both the SV front seat, passenger-side experimenter and POV driver were trained General Motors Milford Proving Ground test drivers who had previous experience conducting brake tests. The SV and the POV test drivers communicated during the study via digital radio communication.

3.9.4 Data Acquisition System

The data acquisition system used was identical to that used in CAMP Study 3.

3.9.5 Procedure and Design

Procedures Before and After Trials

The procedures used were identical to those used in Study 2, with the exception of the test instructions. The test instructions given before and after the Surprise Moving trial are shown in Appendix A14 and Appendix A15, respectively.

Test Phases / Driver Instructions

As in Study 3, the Surprise Moving Trial in this study occurred during the first phase of the study. In this first phase, the computer again was allegedly "learning" driver's normal following behavior for a later "automatic distance control" phase. The backseat experimenter engaged the driver in the same structured *Question & Answer* (*Q & A*) background information dialogue used in Study 3. This dialogue was interrupted by the following, which requested the driver to search for a (non-existent) indicator light located at the head-down, conventional instrument panel:

> *"Have you noticed the indicator light by the dashboard? It is located below the tachometer on the dash. It is a little blue-green indicator that is a little car with bars in front of it. I know it has been coming on. Can you find it? Once you find it I need you to tell me how may bars are in front of the car."*

While the driver was visually searching for the indicator, the Surprise Moving Trial was introduced under the same POV conditions (30 mph speed, -0.37 g deceleration, no brake lights) used in Study 2 and Study 3. This surprise trial technique will be referred to as the "*Head-Down Telltale Search"* surprise technique. As in Study 3, drivers were completely unaware the vehicle was equipped with a FCW system crash alert. After the Surprise Moving Trials, drivers were asked a series of questions about what they noticed coming on or happening inside the car before they began braking. These questions were identical to those used in Study 3.

During the second phase of this study, drivers experienced trials in which the surrogate target was moving. The driver was instructed to follow the POV at their "normal" following distance while the POV traveled at 30, 45, or 60 mph. After this headway had been attained, the POV braked automatically at a constant deceleration rate of approximately 0.15, 0.27, or 0.36 g's, in the same manner as was used in CAMP Study 1. These types of trials are subsequently referred to as *Alerted Moving Trials*. Drivers were asked to brake in response to the FCW system crash alerts as an attentive driver while approaching a surrogate target moving at 30, 45, or 60 mph. These types of trials are subsequently referred to as *Alerted Moving Trials*.

During this study, two 1-stage, dual-modality crash alerts were examined. These crash alert types are indicated below:

- Steady High Head-Down Display (HHDD) + Non-Speech Tone
- Flashing High Head-Down Display (HHDD) + Non-Speech Tone

Drivers were instructed to brake immediately in response to the crash alert in order to avoid colliding with the artificial car. When the SV came to a complete stop, data collection was halted and the trial was ended. During these Alerted Moving trials, drivers experienced two test blocks of 9 trials each (overall, 18 trials) with the same crash alert experienced during the Surprise Moving Trial. The 9 trials per block were formed by crossing the three POV speeds (30, 45, and 60 mph) with the three POV constant deceleration profiles (-0.15,-0.27, and -0.36 g's). During these 9 trials, drivers experienced three successive trials in each speed condition (each with a different POV braking profile). The second block of trials provided a second repetition of the same conditions in order to examine learning effects. The order of the three approach speeds within a block and the three POV braking profile levels from trial-to-trial were appropriately randomized and counterbalanced.

For crash alert timing, the RDP crash alert timing was employed with a 1.5 second driver brake RT assumption for the Surprise Moving Trial (as in Study 2 and Study 3), and a 0.52 second driver RT assumption employed for the Alerted Moving Trials (as was used during the Alerted Stationary Trials in Study 2) for crash alert timing purposes. The “bail-out” auditory alert for the front seat, passenger-side experimenter was also triggered based on the RDP crash alert timing approach, with assumed inputs of 520 ms driver (test driver) brake RT, and an assumed constant deceleration in response to the crash alert of -0.55 g’s during the 30 mph condition, and -0.60 g’s during the 45 mph and 60 mph conditions. The identical “bail-out” sound used in Study 3 was employed here, as well as the visual barrier placed between the experimenter and front seat experimenter (which prevented the driver from anticipating test driver braking behavior).

Independent Variables Examined

For the Surprise Moving Trial, the between-subjects variables analyzed were crash alert type (Steady HHDD + Non-Speech or Flashing HHDD + Non-Speech), age (younger, middle-aged, or older), and gender (male or female). For the Alerted Moving Trials, the within-subjects variables analyzed were speed (30, 45, and 60 mph), POV braking profile (-0.15, -0.27, or -0.36 g), and repetition (first and second), and the between-subjects variables analyzed were crash alert type (Steady HHDD + Non-Speech or Flashing HHDD + Non-Speech), age (younger, middle-aged, or older), and gender (male or female).

Objective (or Performance) Measures Examined

The same driver performance measures were analyzed as in Study 3, with the exception that end range was not included in this analysis due to the difficulties in interpreting this measure discussed earlier.

Subjective Measures / Questionnaire Data

As in Study 2 and Study 3, immediately after each braking trial, drivers were asked to judge the appropriateness of the FCW system crash alert timing using the 7-point scale ranging from “much too early” to “much too late. These ratings were analyzed for each phase of the study using the same independent variables and analysis approach that was used to analyze the driver performance measures.

In addition, after the Surprise Moving Trial, the alert noticeability questionnaire used in Study 3 was administered to assess what the driver noticed coming on or happening inside the car before they began braking.

3.9.6 Results and Discussion

Overview of Statistical Analysis Approach for Objective Measures

For the analysis of the objective (or performance) measures, an Analysis of Variance (ANOVA) was performed for each relevant performance measure (dependent on whether the lead vehicle was moving or stationary) defined in Table 3-1. Data from the Surprise Moving Trial and Alerted Moving Trials were analyzed separately during the statistical analysis. The criterion set for statistical significance was $p<0.01$ during the analysis of the Alerted Moving Trials, due to the large number of statistical tests carried out (which increases the probability of spuriously significant results, (Hays, 1981)). For the analysis of the Surprise Moving Trial data, the criterion set for statistical significance was $p<0.05$. Unless otherwise noted, all statistically significant results indicated met (and often exceeded) these adopted criterion.

Objective (Or Performance) Measures

Surprise Moving Trial

The between-subjects variables analyzed were crash alert type (Steady HHDD + Non-Speech or Flashing HHDD + Non-Speech), age (younger, middle-aged, or older), and gender (male or female). During 2 of these 24 Surprise Moving Trials, the passenger-side experimenter intervened to assist the driver in coming to a stop. In the one case involving the Steady HHDD + Non-Speech condition, the driver contacted the brake first. In this case, the data obtained at onset of braking was included in the analysis, but any measures obtained throughout or at the end of braking were excluded from the analysis. In the remaining case involving the Flashing HHDD + Non-Speech condition, the passenger-side experimenter contacted the brake first. In this case, none of the data from this trial was included in the analysis. As was mentioned for the two-experimenter intervention cases observed in Study 3, it remains unclear whether these drivers could have avoided impact with the surrogate target without the assistance of the passenger-side experimenter.

As in Study 3, these results did not indicate a main effect of crash alert type (a difference between the Steady HHDD + Non-Speech or Flashing HHDD + Non-Speech conditions) on brake reaction times. The overall mean brake RT was 881 ms, which is 126 ms higher than the mean brake RT found in Study 3 (averaged over these same two crash alert types).

Table 3-39 provides the brake RT distribution (based on 23 RTs) during the Surprise Moving Trials for all drivers. It is worth noting that only two subjects yielded a brake RT higher than the 1.5 second brake RT assumed for crash alert timing purposes. The upper-percentile brake RTs found in Study 3 (see Figure 3-36) are similar to the current data, with nearly identical 85th %tile values, but somewhat higher (0.30 seconds higher) 95th %tile values.

There were no significant main effects of crash alert type. However, there was a Gender x Crash Alert Type interaction for the required deceleration and TTC-Case 1 measures (both measured at

SV braking onset). For the male drivers, the mean required deceleration values for the Steady HHDD + Non-Speech and Flashing HHDD + Non-Speech conditions were -0.40 and -0.33 g's, respectively. For the female drivers, the corresponding mean values were -0.35 and -0.39 g's, respectively. For the TTC-Case 1 measure, for male drivers, the mean values for the Steady HHDD + Non-Speech and Flashing HHDD + Non-Speech conditions were 3.8 and 5.8 seconds, respectively. For the female drivers, the corresponding mean values were 5.1 and 4.4 second, respectively. There was also a Age x Crash Alert Type interaction for the minimum TTC-Case 1 measure. For the younger, middle-aged, and older groups, the mean values for the Steady HHDD + Non-Speech condition were 0.7, 1.9, and 2.0 seconds, respectively. The corresponding mean values for the Flashing HHDD + Non-Speech condition were 1.0, 0.4, and 2.1, respectively. The explanation for these interactions described above are unclear, and in any case, do not distinguish between the two crash alert types investigated.

There were also significant effects of age on TTC-Case 1 at SV braking onset, minimum TTC-Case 1, and peak deceleration throughout braking measure. For the younger, middle-aged, and older age groups, the mean TTC-Case 1 values were 5.9, 4.5, and 4.0 seconds respectively. The corresponding mean minimum TTC-Case 1 values were 0.9, 1.2, and 2.0 seconds, respectively. For the younger, middle-aged, and older age groups, the mean peak deceleration values were -0.52, -0.60, and -0.67 g's, respectively.

In summary, and consistent with Study 3, these objective results did not clearly distinguish between the Steady HHDD + Non-Speech or Flashing HHDD + Non-Speech condition. Overall, the 85th percentile brake RT value during Surprise Moving Trials was nearly identical (within 100 ms) to that observed in Study 2 and Study 3. Across Study 2, Study 3, and the current study (Study 4), 85th percentile brake RT values were 1.21, 1.10, and 1.18 seconds, respectively. However, the 95th percentile brake RT value during Surprise Moving Trials was somewhat higher than observed in previous studies. Across Study 2, Study 3, and the current study (Study 4), 95th percentile brake RT values were 1.38, 1.22, and 1.52 seconds, respectively. For reference and comparison purposes, Table 3-28 provides a list of various percentile values for key variables for this study along with the corresponding values for Study 2 and Study 3 Surprise Moving Trials for comparison purposes (previously shown in Table 3-17 and Table 3-23).

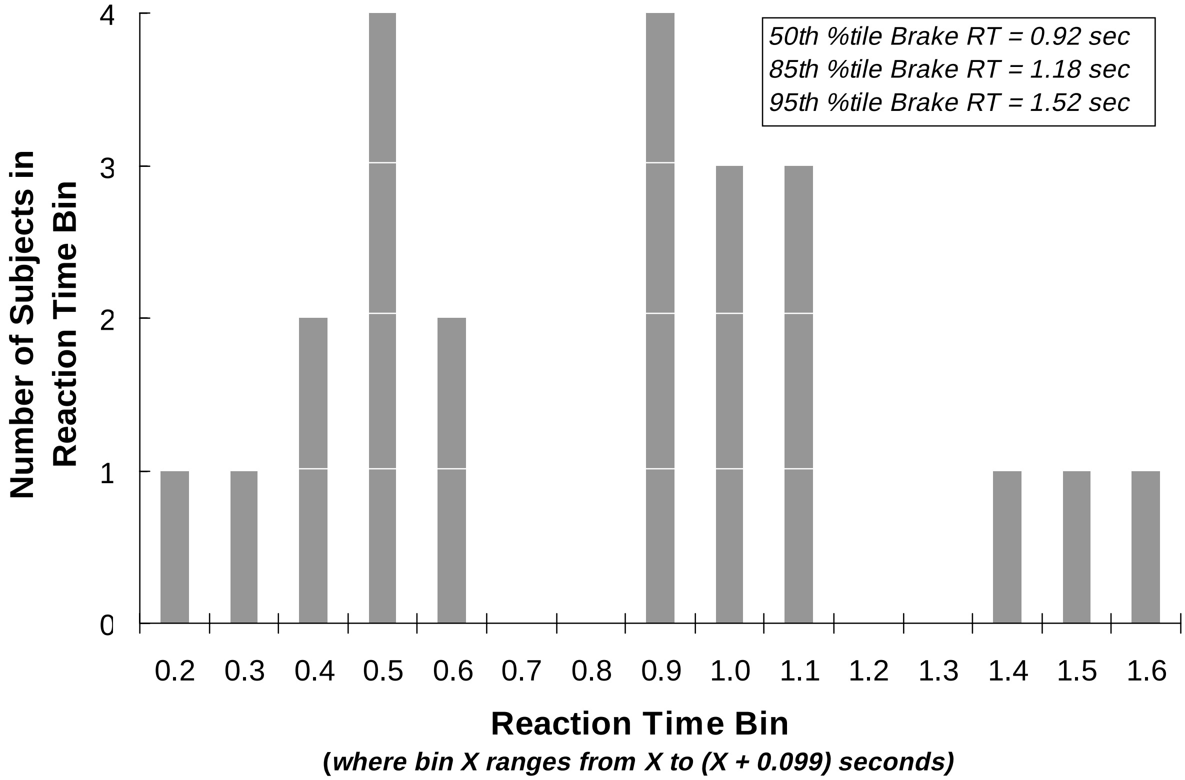

Figure 3-39 Brake Reaction Time Distribution During Surprise Moving Trials (Study 4)

Alerted Moving Trials

The within-subjects variables analyzed were speed (30, 45, and 60 mph), POV braking profile (-0.15, -0.27, or -0.36 g), and repetition (first and second), and the between-drivers variables analyzed were crash alert type (Steady HHDD + Non-Speech or Flashing HHDD + Non-Speech), age (younger, middle-aged, or older), and gender (male or female). Overall, it should be noted that effects involving the variables crash alert type and repetition were largely non-existent in the results reported below.

Results indicated robust main effects of speed and POV braking profile for various performance measures, as well as a robust Speed x Braking Profile interaction for many of these measures. The main effects of speed on variables measured before or at SV braking onset are shown in Table 3-29 and the main effects of speed on variables measured throughout braking are shown in Table 3-30. The main effects of POV braking profile on variables measured before or at SV braking onset are shown in Table 3-31, and the main effects of speed on variables measured throughout braking are shown in Table 3-32. These main effects are provided to help the reader get oriented to the large volume of data analyzed; however, it should be stressed that many of these main effects need to be interpreted in terms of the significant Speed x Braking Profile interactions, which are shown in Table 3-33 and Table 3-34 for variables measured at SV braking onset and variables measured throughout braking, respectively.

The main effects of speed shown in Table 3-29 and Table 3-30 are very systematic and straightforward to interpret. These results indicate that both the SV and POV were very close to the target approach speeds. As speed increased, the following variables increased: range and TTC values (both at SV braking onset and minimum values), minimum headway, required deceleration (albeit very slightly), and brake reaction times. The main effects of POV braking profile shown in Table 3-31 and Table 3-32. As the POV braking profile increased (i.e., the POV braked harder), the following variables *increased*: POV speed, POV deceleration, time headway, range, TTC-Case 1, and required deceleration (all variables listed measured at SV braking onset). In addition, both the actual and peak deceleration values increased as POV braking profile increased. As the POV braking profile increased (i.e., the POV braked harder), the following variables *decreased*: SV deceleration and TTC-Case 2 (both measured at SV braking onset), minimum TTC (both Case 1 and Case 2) and minimum range. In addition, as the POV braking profile increased, both brake RTs and time headway (measured at SV braking onset) somewhat curiously show higher values in the -0.27 g relative to -0.15 and -0.36 g POV braking profile conditions.

As mentioned earlier, many of these main effects of speed and POV braking profile need to be interpreted in terms of the corresponding significant Speed x Braking Profile interactions, which are shown in Table 3-33 for variables measured at SV braking onset, and in Table 3-34 for variables measured throughout braking. At SV braking onset, for the variables listed in Table 3-33, this Speed x Braking Profile interaction indicates that these variables increase with speed (with the exception of the time headway at SV braking onset measure), and that these variables increase with speed at a greater rate in the -0.27 g and -0.36 g POV braking profile conditions (which are very similar, overall) relative to values in the -0.15 g braking profile condition. For nearly all of the variables measured throughout braking, which are shown in Table 3-34 (with the exception of the peak deceleration), nearly the same interaction pattern occurred with the exception that values from the –0.27 g braking profile condition were generally higher than values in the –0.36 g braking profile condition. For the peak deceleration variable, the Speed x Braking Profile interaction (shown Table 3-34) indicated that peak deceleration values increased with speed in a linear fashion in the –0.15 g braking profile condition, remained relatively stable across speed in the –0.27 g braking profile condition, and were higher in the 30 mph relative to the 45 mph and 60 mph conditions.

Table 3-28 Percentile Values for Key Driver Performance Measures During Surprise Moving Trials for Study 4 (Across All Combinations of Age, Gender, and Crash Alert Type Variables)

Time During Which Variable was Measured	Dependent Measure (unit)	15th %tile Value	50th %tile Value	85th %tile Value
At POV Braking Onset	Time Headway (sec)	1.0 *(1.0/1.1)*	1.6 *(1.5/1.6)*	2.2 *(1.9/2.1)*
At SV Braking Onset	Brake Reaction Time (sec)	0.50 *(0.59/0.46)*	0.92 *(0.84/0.82)*	1.18 *(1.23/1.10)*
	Required Deceleration (g)	-0.30 *(-0.28/-0.26)*	-0.38 *(-0.33/-0.32)*	-0.42 *(-0.42/-0.40)*
Throughout Braking	Braking Distance (feet)	78 *(75/86)*	92 *(94/103)*	115 *(105/115)*
	Actual Deceleration (g)	-0.33 *(-0.35/-0.30)*	-0.42 *(-0.42/-0.36)*	-0.47 *(-0.47/-0.44)*
	Peak Deceleration (g)	-0.49 *(-0.53/-0.44)*	-0.59 *(-0.60/-0.55)*	-0.71 *(-0.77/-0.64)*
	Minimum Headway (g)	0.2 *(0.6/0.5)*	0.9 *(1.2/1.3)*	1.6 *(1.6/1.7)*
	Minimum Range (feet)	1 *(5/4)*	10 *(17/15)*	21 *(28/23)*

Note: Numbers shown in parenthesis indicate corresponding values from Study 2 and Study 3 Surprise Moving Trials. Within a set of parenthesis, the left-hand value refers to the corresponding value obtained in Study 2 and the right-hand value refers to the corresponding value obtained in Study 3.

Table 3-29 Significant Main Effects of Speed Condition on Various Driver Performance Measures Analyzed at or Before SV Braking Onset During Alerted Moving Trials (Study 4)

	At POV Braking Onset	At SV Braking Onset							
Speed Condition	**POV Speed (mph)**	**Brake Reaction Time (sec)**	**SV Speed (mph)**	**SV Decel. (g)**	**POV Decel. (g)**	**Range (feet)**	**TTC/ Case 1(sec)**	**TTC/ Case 2(sec)**	**Req. Decel. (g)**
30 mph	30.8	0.499	30.6	-0.02	-0.27	57	3.9	2.3	-0.336
45 mph	45.6	0.547	45.4	-0.03	-0.26	84	4.9	2.8	-0.341
60 mph	60.8	0.578	59.9	-0.04	-0.26	120	5.4	3.3	-0.347

Table 3-30 Significant Main Effects of Speed Condition on Various Driver Performance Measures Analyzed Throughout SV Braking Onset During Alerted Moving Trials (Study 4)

	Throughout Braking				
Speed Condition	**Actual POV Decel. (g)**	**Min. TTC / Case 1 (sec)**	**Min. TTC / Case 2 (sec)**	**Min. Time Head-way (sec)**	**Min. Range (feet)**
30 mph	-0.260	1.7	2.1	0.7	13
45 mph	-0.262	2.5	2.7	0.9	22
60 mph	-0.257	3.2	3.2	1.0	37

Table 3-31 Significant Main Effects of POV Braking Profile Condition on Various Driver Performance Measures Analyzed at SV Braking Onset During Alerted Moving Trials (Study 4)

	At SV Braking Onset									
Braking Profile Condition	**Brake RT (sec)**	**SV Speed (mph)**	**SV Decel. (g)**	**POV Speed (mph)**	**POV Decel. (g)**	**Range (feet)**	**Time Head-way (sec)**	**TTC / Case 1 (sec)**	**TTC / Case 2 (sec)**	**Req. Decel. (g)**
0.15 g	0.515	44.8	-0.031	19.1	-0.15	75	1.2	3.9	3.0	-0.25
0.27 g	0.570	45.6	-0.029	32.3	-0.27	91	1.4	5.2	2.9	-0.35
0.36 g	0.539	45.5	-0.027	43.8	-0.37	95	1.4	5.1	2.6	-0.43

Table 3-32 Significant Main Effects of POV Braking Profile Condition on Various Driver Performance Measures Analyzed Throughout SV Braking Onset During Alerted Moving Trials (Study 4)

	Throughout Braking						
Braking Profile Condition	**Actual POV Decel. (g)**	**Actual Decel. (g)**	**Peak Decel. (g)**	**Min. TTC / Case 1 (sec)**	**Min. TTC / Case 2 (sec)**	**Min. Time Headway (sec)**	**Min. Range (feet)**
0.15 g	-0.15	-0.30	-0.58	2.8	2.8	0.8	29
0.27 g	-0.27	-0.39	-0.64	2.7	2.8	1.0	16
0.36 g	-0.36	-0.48	-0.74	1.8	2.3	0.8	17

In addition, there were main effects of age on POV speed at POV braking onset, SV speed at SV braking onset, and the peak deceleration measures. For the younger, middle-aged, and older age groups, the mean POV speeds at POV braking onset were 46.1, 45.5, and 45.6 mph, respectively. The corresponding means for mean SV speed at SV braking onset were 45.0, 45.2, and 44.7 mph, respectively. For the younger, middle-aged, and older age groups, the mean peak deceleration values were –0.58, -0.63, and –0.75 g's, respectively. This latter result is consistent with the pattern found across age groups during Surprise Moving Trials.

There were only a few, isolated higher-order interactions beyond the numerous Speed x Braking Profile interactions described above. For the minimum range measure, there was a Gender x Speed interaction. For the male drivers, the mean minimum range for the 30, 45, and 60 mph conditions were 12, 17, and 28 feet, respectively. For the female drivers, the corresponding means were 13, 27, and 45 feet, respectively. For the time headway at POV braking onset measure, there was a (4-way) Age x Gender x Speed x POV Braking Profile interaction. The pattern of results for this measure was very unstable across conditions.

For the POV speed at SV braking onset measure, there was a (4-way) Age x Crash Alert Type x POV Braking Profile interaction x Repetition interaction. Results from the middle-age group appear to be the source of this interaction. For the Flashing HHDD + Non-Speech condition/middle-age group combination, POV speed at SV braking onset decreased as POV deceleration increased. In contrast, for the Steady HHDD + Non-Speech condition/middle-age group combination, POV speed at SV braking onset was similar in the -0.15 and -0.36 g POV braking profile conditions, and lower than the corresponding speeds in the -0.27 g POV braking profile conditions. For the POV actual deceleration measure, there was a (4-way) Age x Crash Alert Type x Speed x Repetition interaction, and a (5-way) Age x Gender x Crash Alert Type x Speed x Repetition interaction. The effects of these interactions were very small, as the mean values for this measure varied between –0.25 to –0.27 g's across all cell combinations of this 5-way interaction.

Table 3-33 Significant Speed x POV Deceleration Profile Interaction Effects for Various Driver Performance Measures Measured at SV Braking Onset During Alerted Moving Trials (Study 4)

Performance Measure at SV Braking Onset	Speed	POV Deceleration Profile -0.15 g	POV Deceleration Profile -0.27 g	POV Deceleration Profile - 0.36 g
Range (feet)	30 mph	53	60	59
	45 mph	74	87	91
	60 mph	97	127	135
Time Headway (sec)	30 mph	1.2	1.3	1.3
	45 mph	1.1	1.3	1.4
	60 mph	1.1	1.4	1.5
TTC / Case 1 (sec)	30 mph	3.7	4.1	3.9
	45 mph	3.8	5.6	5.3
	60 mph	4.1	5.9	6.1
TTC / Case 2 (sec)	30 mph	2.6	2.3	2.0
	45 mph	2.9	2.9	2.6
	60 mph	3.3	3.5	3.2
POV Speed (mph)	30 mph	20.3	19.0	18.0
	45 mph	31.8	33.3	31.8
	60 mph	43.3	44.9	43.1

Table 3-34 Significant Speed x POV Deceleration Profile Interaction Effects for Various Driver Performance Measures Measured either Throughout or at the End of SV Braking During Alerted Moving Trials (Study 4)

		POV Deceleration Profile		
Performance Measure	**Speed**	**-0.15 g**	**-0.27 g**	**- 0.36 g**
Peak Deceleration (g)	30 mph	-0.54	-0.64	-0.78
	45 mph	-0.59	-0.62	-0.71
	60 mph	-0.63	-0.65	-0.72
Min. Time Headway (sec)	30 mph	0.9	0.8	0.5
	45 mph	0.8	1.0	0.8
	60 mph	0.8	1.1	1.1
Min. TTC / Case 1 (sec)	30 mph	2.6	1.6	0.9
	45 mph	2.8	2.9	1.8
	60 mph	3.1	3.7	2.7
Min. TTC / Case 2 (sec)	30 mph	2.5	2.1	1.6
	45 mph	2.8	2.8	2.3
	60 mph	3.1	3.3	3.1
Min. Range (feet)	30 mph	21	10	6
	45 mph	28	24	14
	60 mph	37	44	30

Comparison of Brake Reaction Times During the Surprise Moving Trial Versus the Alerted Moving Trials Study Phases

This study, relative to Study 2 and Study 3, provided the best opportunity to sensitively compare drivers RTs during surprise, unexpected braking conditions relative to comparable alerted, expected braking conditions. As argued before, it is felt that performance during the (alerted) Follow-On Moving trials in the previous studies may have been impacted by the driver's ability to immediately recover from the Surprise Moving Trial and follow and stay focused on subsequent experimenter instructions. In this study, drivers experienced the "alerted" version of the Surprise Moving Trial (30 mph /-0.36 g POV braking profile) twice in the midst of a set of Alerted Moving Trials, and hence were likely to provide more stable, reliable RT performance. The Surprise Moving Trial: Alerted Moving Trial RT ratio was 1.8, 2.6, 3.3, and with respect to the 50th, 85th, and 95th percentile RT values for these two study phases. These ratios may have potential future use for conditions under which a surprise, unexpected braking event is not feasible. It is also worth noting note that the spread of driver RTs between the 15th percentile and 85th percentile values was 3.8 times higher during the Surprise Moving Trial relative to that observed during the corresponding "alerted" version of this trial during Alerted Moving Trials.

Subjective Measures / Questionnaire Data

Crash Alert Timing Ratings

<u>Surprise Moving Trial</u>
The between-subjects variables analyzed were crash alert type (Steady HHDD + Non-Speech or Flashing HHDD + Non-Speech), age (younger, middle-aged, or older), and gender (male or female). Once again, in this study phase, the RDP crash alert timing was used. Results indicated no statistically significant effects, with an overall rating of 4.4 (closest to "just right"). The histogram provided in Figure 3-40 shows the percent of timing responses at each point along the crash rating scale. Across all drivers, 23 total ratings were made. This data indicates that 61%, 35%, and 4% of the timing responses were "just right", "slightly late", "moderately late", respectively.

Relative to the crash alert timing ratings obtained during Surprise Moving Trials in Study 2 and Study 3, drivers in this study rated the alert to have occurred later on the crash alert timing scale (compare Figure 3-40 to both Figure 3-34 and Figure 3-37). However, all but one of the ratings in this study were either "just right" or slightly late". This difference in timing ratings across studies may be attributable to the slower overall brake RTs obtained in the this study relative to those found during Surprise Moving Trials in Study 2 and Study 3.

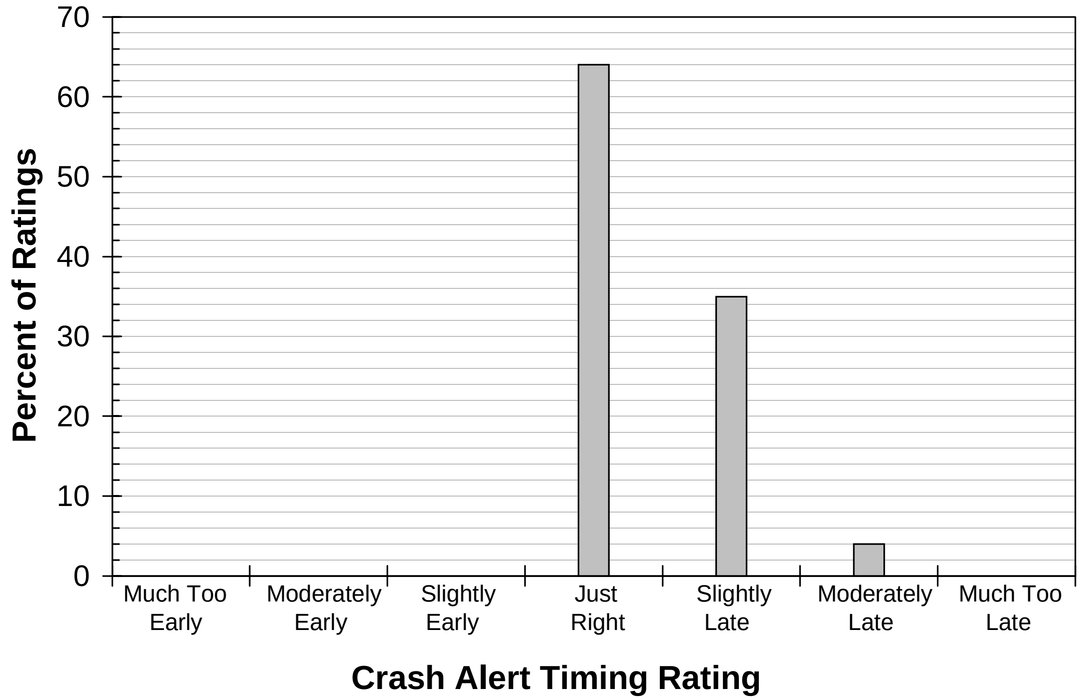

Figure 3-40 Histogram of Subjective Crash Alert Timing Ratings During Surprise Moving Trials (Study 4)

Alerted Moving Trials

The within-subjects variables analyzed were speed (30, 45, and 60 mph), POV braking profile (-0.15, -0.27, or -0.36 g), and repetition (first and second), and the between-drivers variables analyzed were crash alert type (Steady HHDD + Non-Speech or Flashing HHDD + Non-Speech), age (younger, middle-aged, or older), and gender (male or female). In the 30, 45, and 60 mph conditions, mean crash alert timing ratings were 4.8, 4.5, and 4.3, respectively. In the -0.15, -0.28, and -0.36 g POV braking profile conditions, mean crash alert timing ratings were 4.8, 4.3 and 4.5, respectively. However, these main effects need to be interpreted in terms of the Speed x Braking Profile interaction. This interaction indicated that the mean crash alert timing ratings in the -0.15 g braking profile condition were relatively stable across speeds (mean rating ranging from 4.7 - 4.8), whereas the ratings at the two higher braking profile conditions decreased (i.e., were judged “earlier”) as speeds increased. In the -0.27 g braking profile condition, mean crash alert timing ratings at the 30, 45, and 60 mph conditions were 4.6, 4.2, and 4.0, respectively. In the -0.36 g braking profile condition, mean crash alert timing ratings at the 30, 45, and 60 mph conditions were 5.0, 4.3, and 4.0, respectively. Hence, the difference between these two higher braking profile conditions was primarily restricted to the 30 mph condition.

A more insightful look at these crash alert timing data is provided in Figure 3-41. This figure shows the percent of timing responses at each point along the crash rating scale as a function of each Speed x Braking Profile combination. (For each combination, across all drivers, 48 total ratings were made). This figure averages over the independent variables of repetition, crash alert type, age, and gender. For comparison purposes, results from Study 2 found with Alerted Stationary Trials are also provided in Figure 3-41. (For each of the two approach speed conditions during these latter trials, across all drivers, 96 total ratings were made). On the one hand, there were very few “much too early” and “moderately early” ratings across all Speed/POV Braking Profile combinations during the Alerted Moving Trials. On the other hand, there were 6 Speed/POV Braking Profile combinations during these trials in which the percent of combined “moderately late” and “much too late” responses ranged between about 15%-25%. As can be seen in Figure 3-41, 3 of these 6 combinations involved the 30 mph condition in which the lead vehicle was moving, and 3 of these 6 combinations occurred when the POV braking profile was -0.15 g’s.

Overall, as can be seen in Figure 3-41, the crash alert timing ratings found during the Alerted Moving Trials in this study were judged as “later” on the crash alert timing rating scale relative to those obtained during the Alerted Stationary Trials in Study 2. This rating difference may be due to the relatively greater uncertainty for the driver surrounding the behavior of the surrogate target (lead vehicle) during Alerted Moving Trials relative to Alerted Stationary Trials. In the former case, the lead vehicle could brake at various levels, whereas in the latter case, the surrogate target was parked.

Summary of Crash Alert Timing Ratings Findings

In summary, these crash alert timing ratings are generally consistent with those found in the previous Study 2 and Study 3, and provide further evidence that the crash alert timing approach directly derived/modeling from the CAMP Study 1 findings (i.e., the RDP crash alert timing) does an excellent job from a driver preference perspective under a wide range of driver expectancy and kinematic conditions. Furthermore, it should be kept in mind that for the Speed/POV Braking Profile combinations discussed above in which 15%-25% of the drivers rated the alert as either “moderately late” or “much too late”, drivers were still able to avoid colliding with the surrogate target.

It is also interesting to compare the crash alert timing ratings in this study found during Surprise Moving Trials to those found under identical POV speed/POV braking profile conditions (30 mph /-0.36 g) during Alerted Moving Trials (see Figure 3-40 and Figure 3-41). The mean crash alert timing rating during the Surprise Moving Trial and the alerted version of this trial were 4.4 and 5.0, respectively. It should be noted that the assumed driver RT (which was input into the RBD crash alert timing algorithm) was about 1 second less during the Alerted Moving Trial.

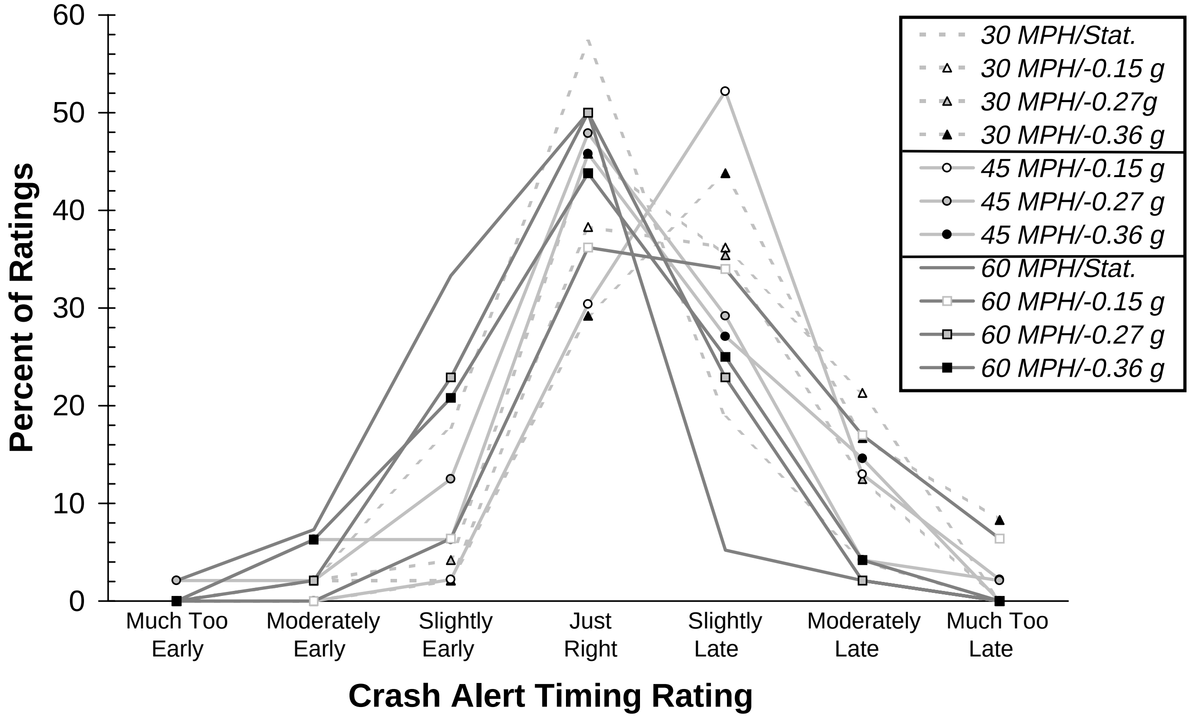

Figure 3-41 Percent of Crash Alert Timing Ratings with the RDP Crash Alert Timing Approach During Alerted Moving Trials (Study 4) and Alerted Stationary Trials (Study 2) Across All Speed/POV Braking Profile Combinations Tested

Alert Noticeability Questionnaire

Results from this questionnaire (administered immediately after the Surprise Moving Trial) are shown in Table 3-35, along with results from Study 3 for comparison purposes (previously shown in Table 3-25). The identical criterion for “noticeability” employed in Study 3 across the various crash alert modality components was employed in the current study. Across both alert types evaluated in this study (Steady HHDD + Non-Speech, Flashing HHDD + Non-Speech), the non-speech component of the alert was noticed by all drivers. In contrast, as in Study 3, the noticeability of the visual alerts varied considerably across these two crash alert types. In the Steady HHDD + Non-Speech and the Flashing HHDD + Non-Speech conditions, the visual alerts were noticed by 4 of 12 drivers and 10 of 12 drivers, respectively. These results are very consistent with those found in Study 3, and hence, the change in the surprise trial technique from Study 3 to Study 4 had no substantial impact on the pattern of alert noticeability results across crash alert types. For the interested reader, a more detailed breakdown of these data beyond the high-level "noticeability" criterion is provided in Appendix A17.

The visual alert data from this study and Study 3 suggest that flashing the HHDD may be prudent in order to improve the noticeability of the HHDD (which may also be true for the HUD), particularly when this alert is coupled only with an auditory crash alert since some drivers may not hear the auditory alert under some conditions. Once again, it should be noted that under more typical conditions in which the driver would be aware his/her vehicle was equipped with a visual crash alert, the probability of noticing these visual alerts may increase.

Table 3-35 Noticeability of Visual and Auditory Alerts Across the "Flashing HHDD+Non-Speech" and "Steady HHDD+ Non-Speech" Crash Alert Types (Studies 4 and 3)

Crash Alert Type	Visual Alert Noticed?	Auditory Alert Noticed?
Flashing HHDD + Non-Speech	10/12 (*8/12*)	12/12 (*12/12*)
Steady HHDD + Non-Speech	4/12 (*5/12*)	12/12 (*12/12*)

<u>Note:</u> Numbers shown in parentheses indicate corresponding values from Study 3, Surprise Moving Trials.

3.9.7 Follow-up Analysis on Brake Reaction Time Findings

A better understanding of these brake RT results was attained by conducting a frame-by-frame video analysis of the driver's eye position at alert onset, and observing any subsequent eye movements made to the visual alert (prior to and after braking onset). The relationship of these eye movement patterns to both visual alert noticeability and brake RT measures were then explored, to the extent that was possible given the limited data set. This analysis is shown in Table 3-36. Corresponding results from Study 3 are also shown in this table (in smaller, italicized font), which follow the same pattern as those reported below.

Table 3-36 Detailed Gaze Location, Eye Movement, and Visual Alert Noticeability Analysis for the "Steady HHDD + Non-Speech" and "Flashing HHDD + Non-Speech" Crash Alert Types for Study 4 Data and Corresponding Study 3 Data (Data from this latter study in indicated in italicized, smaller font)

Gaze location of driver at alert onset / Number of drivers at gaze location at alert onset	**Crash Alert Type / Number of drivers at gaze location at alert onset with this Crash Alert Type**	**Number of drivers who noticed visual alert / Number of possible drivers in Gaze Location x Crash Alert Type cell**	**Number of drivers who…**			**Number of drivers who noticed visual alert without pausing to look at the alert / Number of possible drivers in Gaze Location x Crash Alert Type cell who did not pause to took at alert**
			…paused to look at visual alert *prior to braking* / Number of possible drivers in Gaze Location x Crash Alert Type cell	… paused to look at visual alert *after braking* / Number of possible drivers in Gaze Location x Crash Alert Type cell	…did not pause to look at visual alert / Number of possible drivers in Gaze Location x Crash Alert Type cell	
Forward Scene / n=7 *(n=19)*	Steady HHDD + Non-Speech / n=3 *(n=11)*	1 / 3 *(5 / 11)*	0 / 3 *(1 / 11)*	1 / 3 *(2 / 11)*	2 / 3 *(8 / 11)*	0 / 2 *(2 / 8)*
	Flashing HHDD + Non-Speech / n=4 *(n=8)*	4 / 4 *(5 / 8)*	0 / 4 *(1 / 8)*	2 / 4 *(3 / 8)*	2 / 4 *(4 / 8)*	2 / 2 *(5 / 8)*
Conventional Instrument Panel / n=12	Steady HHDD + Non-Speech / n=6	0 / 6	0 / 6	0 / 6	6 / 6	0 / 6
	Flashing HHDD + Non-Speech / n=6	4 / 6	2 / 6	0 / 6	4 / 6	2 / 4

Note: Only subjects for whom the location of their gaze immediately prior to alert could be scored as either at the forward scene or at the conventional (head-down) instrument panel location were included in this analysis. For both Study 4 and Study 3, this meant 5 of the 24 subjects (12 possible subjects per crash alert type) were excluded from this analysis. Note that there was no compelling reason to look down in Study 3 during the Surprise Moving Trial, and hence, the Study 3 data is concentrated for cases where gaze location at alert onset was the forward scene.

Table 3-37 Individual Brake Reaction Times for Drivers Who Were Gazing at Either the Conventional Instrument Panel or Forward Scene at Crash Alert Onset as a Function of Crash Alert Type and Age Group (With Gender also Indicated)

		Driver Gaze Location at Alert Onset	
Crash Alert Type	**Age Group**	**Conventional Instrument Panel**	**Forward Scene**
Steady HHDD + Non-Speech	Young		0.49 (female) 0.52 (female)
	Middle-Aged	0.99 (female) 1.09 (male) 1.15 (male)	
	Older	0.55 (male) 1.15 (male) 0.95 (female)	0.32 (female)
Flashing HHDD + Non-Speech	Young		0.52 (male) 0.45 (female) 0.65 (male) 0.55 (female)
	Middle-Aged	1.52 (female) 1.69 (female)	
	Older	1.02 (female) 0.62 (male) 0.92 (female)	

Note: * Denotes subject who paused to look at the visual alert prior to braking. Both of these subjects avoided impacting the surrogate (lead vehicle) target without braking intervention from the passenger-side experimenter.

First, driver's eye position at alert onset was scored and placed into various gaze location categories. As can be seen in the first column of Table 3-36, 7 and 12 drivers were categorized into the "forward scene" and (head-down) "conventional instrument panel" categories, respectively. (Five drivers from this study were excluded from this analysis. Three drivers could not be scored due to either poor image quality or eye closure at alert onset, one driver was looking at the rear-view mirror at alert onset, and one driver happened to be looking at the HHDD at alert onset.) Hence, despite the experimenters' best attempts during these Surprise Moving Trials to time the crash alert to occur when the driver was looking down at the conventional instrument panel, about 1/3 of the drivers happened to be looking at the forward scene when the alert was presented. This is not surprising given that drivers do not typically make long, sustained visual fixations to the instrument panel, and instead typically opt for making a series of relatively short head-down visual fixations to perform an in-vehicle task. Between these fixations, drivers typically visually check (i.e., fixate) the forward scene.

Finally, it should be noted there was a strong age effect associated with the driver gaze location at brake onset (which can be seen in Table 3-37, described below). Six of the 7 drivers who were looking at the forward scene at crash alert onset were younger-aged drivers. In sharp contrast, all of the 11 drivers who were looking at the conventional instrument panel at crash alert onset were either middle-aged or older-age drivers. Hence, for reasons that are somewhat unclear, a much higher degree of success was attained with getting middle-aged and older-aged drivers in terms of getting them to look at the conventional instrument panel at alert onset. As a consequence, any comparisons between brake RT as a function of driver gaze location are necessarily confounded by driver age effects.

As can be seen in the second column of Table 3-36, these 7 “forward scene” and 12 “conventional instrument panel” gaze locations at alert onset are further broken down as a function of crash alert type (Steady HHDD + Non-Speech versus Flashing HHDD + Non-Speech). Fortunately, there are nearly an equal number of drivers for each crash alert type within each gaze location at alert onset category (forward scene versus conventional IP), which allows one to better explore the effects of crash alert type as a function of gaze location of the driver at alert onset.

As can be seen in the third column of Table 3-36, independent of driver’s gaze location at alert onset, it appears the probability of the driver noticing the visual alert is much higher for the Flashing HHDD + Non-Speech condition. This same trend was true for the Study 3 results, particularly if one includes drivers who were not looking in these two gaze location categories at alert onset (see Table 3-25).

Columns four through six of Table 3-36 indicate the number of drivers who paused to look at the visual alert *prior to braking* (column four), the number of drivers who paused to look at the visual alert *after braking* (column five), and the number of drivers who did not pause to look at the visual alert (column six). These data indicate that the two drivers who looked at the visual alert prior to braking were looking at the conventional instrument panel at the onset of the Flashing HHDD + Non-Speech alert. Furthermore, these two drivers (both middle-aged females) experienced the two longest brake RTs (1.52 and 1.69 seconds) in Study 4. Table 3-37 provides each subject’s brake RT in this analysis as a function of crash alert type and gaze location at alert onset. These limited data suggest *any* RT slowing effects caused by the Flashing HHDD + Non-Speech alert are due to actually pausing to look at the visual alert, rather than the due to flashing *per se*. For the case in which drivers were looking at the conventional instrument panel at the onset of the alert, and who did not fixate the alert prior to braking, there does not appear to be any difference in RT between the Steady HHDD + Non-Speech and Flashing HHDD + Non-Speech conditions with the available data. A similar “non-difference” between these crash alert types can be observed for the young drivers who were looking forward at the onset of the alert. These isolated brake RT slowing effects which are *potentially* due to pausing to look at the visual alert prior to braking onset need to put into the following context.

First, for these two drivers (as was true for all 19 drivers in this analysis), it was their first experience with the crash alert. Under more typical conditions, the driver would be aware his/her vehicle was equipped with a visual crash alert. The current experimental conditions in all likelihood increased any novel tendency drivers may have to choose to pause and look at the visual alert prior to braking. It seems likely that under the more typical conditions described above, drivers would not choose to pause to look at the alert (in part because of the compelling nature of rapidly approaching a vehicle ahead), and would be more capable of "peripherally" using the information provided by the location and flashing nature of this visual indicator without a direct fixation. Indeed, of the four remaining "novice" drivers who were also looking at the conventional instrument panel at the onset of the Flashing HHDD + Non-Speech alert, two of these drivers did not pause to look at the visual alert, and two of the drivers noticed the visual alert during this first experience without actually pausing to look at the alert.

Second, both of the two drivers mentioned above were still able to avoid impact with surrogate target without braking intervention by the passenger-side experimenter. Furthermore, this was also true for both drivers in Study 3 who paused to look at the visual alert prior to braking (see Table 3-36, column 4), who were both looking at the forward scene at crash alert onset. It remains unclear whether the brake RTs may have been actually slower or faster for these particular Study 4 and Study 3 drivers if they had experienced the Steady HHDD + Non-Speech alert (or no visual alert at all). Indeed, the flashing HHDD may have played a critical role in allowing these drivers to successfully avoid impacting the target by orienting the driver's visual attention from the in-vehicle visual search task to the road ahead.

Third, as can be seen in the rightmost column of Table 3-36, given that drivers did not pause to look at the alert, 0 of the 8 possible drivers experiencing the Steady HHDD + Non-Speech alert noticed the visual alert, and 4 of the 6 possible drivers experiencing the Flashing HHDD + Non-Speech alert noticed the visual alert. The corresponding data from Study 3 were as follows. Given that drivers did not pause to look at the alert, 2 of the 8 possible drivers experiencing the Steady HHDD + Non-Speech alert noticed the visual alert, and 5 of the 8 possible drivers experiencing the Flashing HHDD + Non-Speech alert noticed the visual alert. Clearly, together with the data reported above, this limited data set clearly indicate that the likelihood of noticing and fixating the telltale is substantially higher in the Flashing HHDD + Non-Speech condition. Furthermore, the likelihood of noticing the telltale without actually pausing to look at the telltale is substantially higher in the Flashing HHDD + Non-Speech condition. Clearly, in terms of accommodating drivers who may not hear the alert sound (either due to hearing impairments and/or competing noises) and potentially facilitating these drivers to look away from inside of the vehicle and toward the forward scene, these limited data provide support for using a Flashing versus Steady HHDD.

Fourth, for drivers who were looking at the forward scene at alert onset, none of the four drivers in the Flashing HHDD + Non-Speech in Study 4 paused to look at the visual alert. For the Study 3 drivers who were looking at the forward scene at alert onset, only 1 of the 8 drivers in the Flashing HHDD + Non-Speech condition paused to look at the visual alert. As is pointed out in Chapter 2 of this report, the percent of rear-end collisions which can be attributed to drivers looking head-down while performing an in-vehicle task appears to be relatively small compared to the percent of rear-end collisions which can be attributed to drivers become inattentive for a non-compelling reason (e.g., daydreaming). Furthermore, once again, neither of the two drivers who were looking head-down while performing the in-vehicle (visual search) task, and who *may* have experienced RT slowing due to pausing to look at the alert, needed braking assistance from the passenger-side experimenter to avoid colliding with the surrogate (lead vehicle) target.

In summary, these data suggest that a flashing HHDD visual crash alert is more likely to be noticed than steady HHDD visual crash alert, even when the driver does not actually pause to look at the visual telltale. Clearly, in terms of accommodating drivers who may not hear the alert sound either due to hearing impairments and/or competing noises, and potentially facilitating these drivers to look away from inside of the vehicle and toward the forward scene, these limited data provide support for using a Flashing versus Steady HHDD. Furthermore, any potential brake RT slowing effect experienced by a relatively limited number of drivers in this study is hypothesized to be due to a novelty effect. Assuming this slowing effect occurred, the drivers who paused to look at the visual alert prior to braking were still able to avoid the impact with the surrogate target without braking intervention by the passenger-side experimenter. Indeed, the flashing HHDD may have played a critical role in allowing these drivers to avoid impact by orienting the driver’s visual attention from the in-vehicle visual search task to the forward scene ahead. Finally, even if the brake RT slowing effect mentioned above occurred, this phenomenon appears to limited to when the driver was looking at the conventional instrument panel (as opposed to the forward scene) prior to braking onset. The percent of rear-end collisions which can be attributed to drivers looking head-down while performing an in-vehicle task is relatively small compared to the percent of rear-end collisions which can be attributed to drivers who are looking at the forward scene and become inattentive for a non-compelling reason.